reduced by the Callendar and Dickson methods. A table was given showing the results for seven thermometers, viz., two of platinum, one of gold, silver, copper and iron, and one of platinum-rhodium alloy.

It is noted that the lowest boiling point for hydrogen was given by the gold thermometer. Next to it came one of the platinum thermometers, and then silver, while copper and the iron differ from the gold value by 26 and 32 degrees respectively. The gold thermometer would make the boiling point 23°·5 instead of the 20°·5 given by the gas thermometer. Then the reduction of temperature under exhaustion amounts to only 1° instead of 4° as given by the gas thermometer. The extraordinary reduction in resistance of some of the metals at the boiling point of hydrogen is very remarkable. Thus copper has only 1/105th, gold 1/30th, platinum 1/35th to 1/17th, silver 1/24th the resistance at melting ice, whereas iron is only reduced to 1/8th part of the same initial resistance. The real law correlating electric resistance and temperature within the limits we are considering is unknown, and no thermometer of this kind can be relied on for giving accurate temperatures up to and below the boiling point of hydrogen. The curves are discussed in the paper, and I am indebted to Mr. J. H. D. Dickson and Mr. J. E. Petavel for help in this part of the work.

Helium separated from the gas of the King's Well, Bath, and purified by passing through a U-tube immersed in liquid hydrogen, was filled directly into the ordinary form of Cailletet gas receiver used with his apparatus and subjected to a pressure of 80 atmospheres, while a portion of the narrow part of the glass tube was immersed in liquid hydrogen. On sudden expansion from this pressure to atmospheric pressure a mist from the production of some solid body was clearly visible. After several compressions and expansions, the end of the tube contained a small amount of a solid body that passed directly into gas when the liquid hydrogen was removed and the tube kept in the vapour of hydrogen above the liquid. On lowering the temperature of the liquid hydrogen by exhaustion to its melting point, which is about 16° absolute, and repeating the expansions on the gas from which the solid had separated by the previous expansions at the boiling point or 20°·5, *no mist was seen*. From this it appears the mist was caused by some other material than helium, in all probability neon, and when the latter is removed no mist is seen, when the gas is expanded from 80 to 100 atmospheres, even although the tube is surrounded with solid hydrogen. From experiments made on hydrogen that had been similarly purified like the helium and used in the same apparatus, it appears a mist can be seen in hydrogen (under the same conditions of expansion as applied to the helium sample of gas) when the initial temperature of the expanding gas was twice the critical temperature, but it was not visible when the initial temperature was about two and a half times the critical temperature. This experience applied to interpret the helium experiments would make the critical temperature of the gas under 9° absolute.

Olszewski in his experiments expanded helium from about seven times the critical temperature under a pressure of 125 atmospheres. If the temperature is calculated from the adiabatic expansion starting at 21° absolute, an effective expansion of only 20 to 1 would reach 6°·3, and 10 to 1 of 8°·3. It is now safe to say, helium has been really cooled to 9° or 10° absolute without any appearance of liquefaction. There is one point, however, that must be considered, and that is the small refractivity of helium as compared to hydrogen, which, as Lord Rayleigh has shown, is not more than one-fourth the latter gas. Now as the liquid refractivities are substantially in the same ratio as the gaseous refractivities in the case of hydrogen and oxygen, and the refractive index of liquid hydrogen is about 1·12, then the value for liquid helium should be about 1·03, both taken at their respective boiling points. In other words, liquid helium at its boiling point would have a refractive index of about the same value as liquid hydrogen at its critical point, and as a consequence, small drops of liquid helium forming in the gas near its critical point would be far more difficult to see than in the case of hydrogen similarly situated.

The hope of being able to liquefy helium, which would appear to have a boiling point of about 5° absolute, or one-fourth that of liquid hydrogen, is dependent on subjecting helium to the same process that succeeds with hydrogen; only instead of using liquid air under exhaustion as the primary cooling agent, liquid hydrogen under exhaustion must be employed, and the resulting liquid collected in vacuum vessels surrounded with liquid hydrogen. The following table embodies the results of experience and theory :—

Initial temperature.	Initial temperature.	Critical temperature.	Boiling points.
Liquid helium ? ...	5° ?	2° ?	1° ?
Solid hydrogen ...	15	6	4
Liquid ,, ...	20	8	5 (He ?)
Exhausted liquid air	75	30	20 (H)
52° C.	325	130	86 (Air)
Low red heat ...	760	304	195 (CO_2)

The first column gives the initial temperature before continuous expansion through a regenerator, the second the critical point of the gas that can be liquefied under such conditions, and the third the boiling point of the resulting liquid. It will be seen that by the use of liquid or solid hydrogen as a cooling agent we ought to be able to liquefy a body having a critical point of about 6° to 8° absolute and boiling point of about 4° or 5° absolute. Then, if liquid helium could be produced with the probable boiling point of 5° absolute this substance would not enable us to reach the zero of temperature; another gas must be found that is as much more volatile than helium as it is than hydrogen in order to reach within 1° of the zero of temperature. If the helium group comprises a substance having the atomic weight 2, or half that of helium, such a gas would bring us nearer the desired goal. In the meantime the production of liquid helium is a difficult and expensive enough problem to occupy the scientific world for many a day.

A number of miscellaneous observations have been made in the course of this inquiry, among which the following may be mentioned. Thus the great increase of phosphorescence in the case of organic bodies cooled to the boiling point of hydrogen under light stimulation is very marked, when compared with the same effects, brought about by the use of liquid air. A body like sulphide of zinc cooled to 21° absolute and exposed to light shows brilliant phosphorescence on the temperature being allowed to rise. Bodies like radium that exhibit self-luminosity in the dark, cooled in liquid hydrogen maintain their luminosity unimpaired. Photographic action is still active although it is reduced to about half the intensity it bears at the temperature of liquid air. Some crystals when placed in liquid hydrogen become for a time self-luminous, on account of the high electric stimulation brought about by the cooling causing actual electric discharges between the crystal molecules. This is very marked with some platino-cyanides and nitrate of uranium. Even cooling such crystals to the temperature of liquid air is sufficient to develop marked electrical and luminous effects.

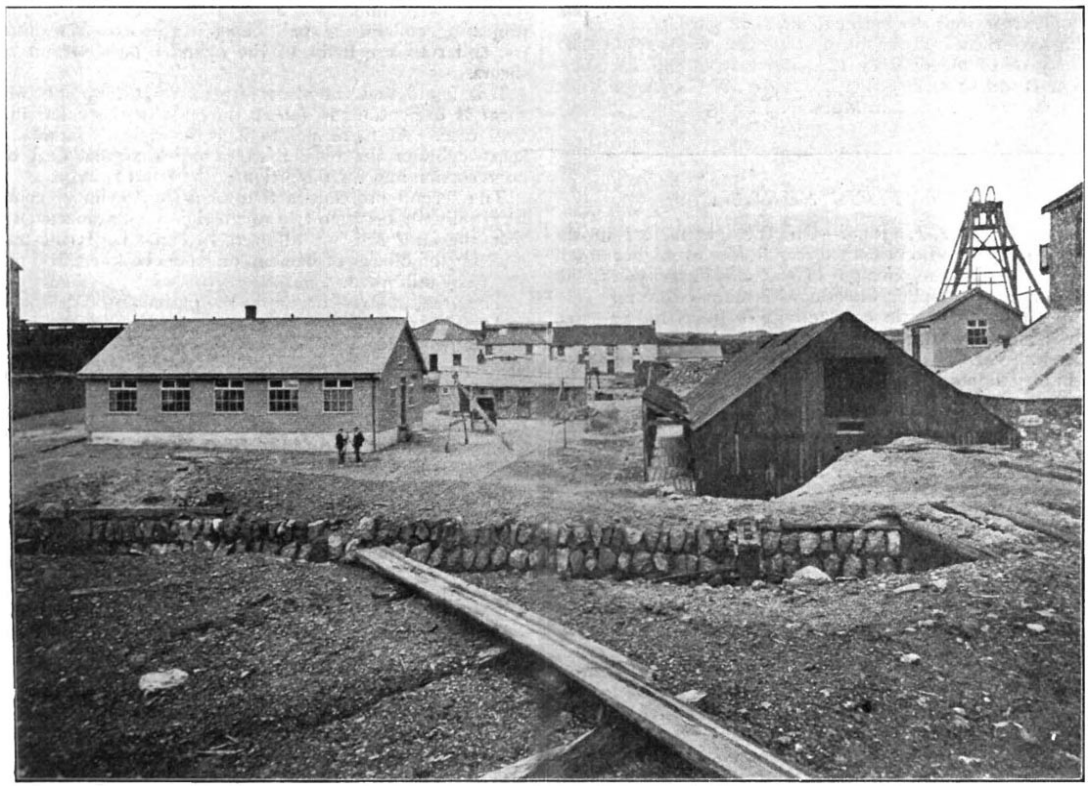
Considering that both liquid hydrogen and air are highly insulating liquids, the fact of electric discharges taking place under such conditions proves that the electric potential generated by the cooling must be very high. When the cooled crystal is taken out of either liquid and allowed to increase in temperature, the luminosity and electric discharges take place again during the return to the normal temperature. A crystal of nitrate of uranium gets so highly charged electrically that, although its density is 2·8 and that of liquid air about 1, it refuses to sink, sticking to the side of the vacuum vessel and requiring a marked pull on a silk thread, to which it is attached, to displace it. Such a crystal rapidly removes cloudiness from liquid air by attracting all the suspended particles on to its surface. The study of pyro-electricity at low temperatures will solve some very important problems.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Education Bill has been abandoned by the Government on account of want of time to consider it adequately during the present session. A short measure dealing with the difficulties which have arisen in connection with the recent judgment as to higher elementary schools and evening continuation schools was introduced in the House of Commons on Tuesday, and it is hoped that the second reading will be taken early next week. The measure proposes to empower county or county borough councils, or technical instruction committees, to make arrangements with School Boards for the continuation during one year of the work to which school funds have been declared to be inapplicable by the Cockerton judgment. Sir Joshua Fitch

writes to the *Times* to point out that this measure is unsatisfactory, for it presupposes that a local educational authority to supersede the School Board is intended to be constituted, and meanwhile entrusts the whole responsibility of maintaining or destroying the higher elementary schools and continuation schools to the county councils, which are not necessarily conversant or in sympathy with them. These schools have been created by the School Boards, and in the case of the higher elementary schools the opportunities they give for scientific study and intellectual culture are of the highest value to national progress. What is required is a short Act of Parliament, which would, for a year or two longer, leave the management and development of these schools in their present hands and provisionally legalise the needful expenditure from the rates. This, Sir Joshua Fitch remarks, "would simply postpone the controversial parts of the abandoned measure for the maturer deliberation of next session, would provide a satisfactory escape from the present *impasse*, and would, it may be hoped, encounter very little opposition."

THE prospectus of the mining school at Camborne for the session 1900-1901 tells the tale of some useful educational work which is being carried on in Cornwall. The chief point, and one for which Mr. W. Thomas, the mining lecturer, deserves great credit, is the existence of a school mine; that is to say, the school is the owner of a tin mine which is worked for educational purposes. Instead of being taught solely by lectures, diagrams and models, the student has to work below ground under the guidance of competent instructors. The school is further equipped with good chemical and assaying laboratories and a special room for teaching the useful Cornish art of "vanning," besides having a large and airy drawing office, a library and a museum. Camborne is close to Dolcoath and other large tin mines, so the student is not confined to the school mine for the purposes of instruction. The fault of the school lies in the fact of many of the lectures being delivered in the evening. Admitting the desirability and necessity of evening classes for young miners who are at work during the day, it seems hard upon the outside student, who is ready to pay full fees, that he should be made to attend lectures from 8 p.m. to 9 p.m., and even later. In the interests of the school this should be changed, even if it necessitates two sets of lectures. The accompanying illustration shows the drawing office, with the mine offices behind it; on the right-hand side



Mine Buildings of Camborne Mining School, Cornwall.

MR. J. PIERPONT MORGAN has given a sum exceeding 1,000,000 dollars for the erection of three buildings for a Harvard medical school.

THE first annual report of the Midland Agricultural and Dairy Institute has been received. The Institute has absorbed the agricultural department of the University College, Nottingham, and now provides courses of instruction in agriculture on practical lines, and calculated to gain the confidence of practical agriculturists. The work is carried on in conjunction with the county councils of Derbyshire, Leicestershire, Lincolnshire (Lindsey) and Nottinghamshire. In addition to courses of instruction for farmers' sons, the Institute undertakes analyses for farmers and conducts experiments of interest to agriculturists at selected centres in the counties named. In a small way its work is similar to that of an agricultural college and experiment station in the United States, and every assistance should be given to enable the work to be extended.

THE Technical Education Board of the London County Council is making arrangements at the Poplar Technical Institute for giving practical instruction in the use of nautical instruments and in marine engineering. A building is being planned which will afford accommodation for marine engineering, naval architecture and navigation, building construction, joiner's work, and plumbing and metal-plate work, with a lecture theatre and classrooms. Practical classes will be conducted in electrical engineering, especially in connection with ships' lighting. The top floor will comprise a large room for nautical instruments and a room for cartography and the exhibition of ships' models, a chemical laboratory, a balance room, and a physical laboratory. Connected with this floor will be a flat roof on which astronomical observations may be made with such instruments as are used on board ship, and it is probable that a small dome will be provided for an equatorial telescope.

may be seen the "pit-head frame," with the winding pulleys, which was erected by the students.

THE Technical Education Board of the London County Council is offering facilities for boys who are leaving, or have recently left, public elementary schools to enter upon a course of training which will fit them to become gardeners. A school of practical gardening has been established at the Royal Botanic Society, Regent's Park, and is now attended by some thirty boys, most of whom are holding scholarships from the Technical Education Board. The boys at this school go through a three-years' course, in which they have a thorough training in practical gardening and also receive instruction in elementary science and botany. The scholarships offered by the Board are open to boys between the ages of fourteen and sixteen, whose parents are resident within the County of London and are in receipt of incomes not exceeding 250*l.* a year. The scholarships provide free tuition for three years at the School of Practical Gardening, and also a maintenance grant rising from 20*l.* a year to 25*l.* a year. There is no examination for these scholarships, but parents are required to sign a declaration to the effect that they intend their sons to become practical gardeners. Full particulars of these scholarships, together with application forms, may be obtained from the secretary of the Technical Education Board, 116 St. Martin's Lane, W.C. Application should be made not later than Monday, July 15.

SCIENTIFIC SERIAL.

Annalen der Physik, June.—On the parameters in the physics of crystals and on directed magnitudes of higher order, by W. Voigt.—On the change of the conductivity of salt solutions in liquid sulphur dioxide with temperature up to the critical point. Electrolytic conductivity in gases and vapours. The absorption spectra of solutions with iodine salts, by A. Hagenbach. Various alkaline salts, chiefly iodides, were dissolved in dry liquid sulphur dioxide and the conductivities measured at temperatures up to and just above the critical point. These salt solutions behave as electrolytes, even up to the critical point. The fact that polarisation occurs, shows that the electricity is conducted in the solution by means of ions. The temperature coefficients are negative between the limits of the experiments (from 20° to 160° C.), with the exception of potassium iodide, which shows a maximum of conductivity at about 90°. In the conductivity curves the critical temperature is clearly shown, although there is no absolute discontinuity at this point. Some interesting observations were made on the state of the dissolved solid when the liquid was just above the critical point, as after the meniscus had vanished the resistance of the vapour differed according as the electrodes were in the upper or lower portion of the tube, this difference disappearing immediately on shaking the tube.—On the second law of thermodynamics, by N. Schiller.—The thermodynamics of saturated solutions, by N. Schiller.—On an improved method for the preparation of photographic plates sensitive to the ultra-violet rays, by V. Schumann. A detailed description of the methods of preparing the emulsion, coating and drying the plates, exposure and development. An example is given showing the increased length of spectrum obtained with these plates as compared with an ordinary dry plate.—On a mechanical representation of the electrical and magnetic phenomena in bodies at rest, by L. Graetz.—On changes of weight during chemical and physical changes, by A. Heydweiller. Various chemical reactions were carried out in closed vessels, and in certain cases slight changes in weight were observed which, in the opinion of the author, were outside the range of possible experimental error.—Researches on electrical discharge in rarefied gases, by W. Wien.—Experiments on the influence of capillarity on the velocity of outflow of liquids, by C. Christiansen.—Communication to the knowledge of the physical properties of silver mirrors, by C. Grimm. A study of the electrical resistance of thin silver mirrors under varying conditions of temperature, light, degree of polish, &c.—On a new experiment in dynamics, by V. v. Niesiolowski-Gawin.—On the behaviour of liquid dielectrics on the passage of an electric current, by E. v. Schweidler.—Stroboscopic methods for the determination of the frequency of alternation and lag of a motor, by G. Benischke.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 6.—"On the Elastic Equilibrium of Circular Cylinders under Certain Practical Systems of Load." By L. N. G. Filon, M.A., B.Sc., Research Student of King's College, Cambridge; Fellow of University College, London; 1851 Exhibition Science Research Scholar. Communicated by Prof. Ewing, F.R.S.

The paper applies the equations of elasticity to the investigation of problems connected with the circular cylinder. The solutions are symmetrical about the axis of the cylinder, and are obtained as infinite series involving circular and Bessel's functions.

The three problems treated of are as follows:—

In the first a cylinder under pull is considered, the pull not being applied by a uniform distribution of tension across the plane ends, but by a given distribution of axial shear over two zones or rings towards the ends of the cylinder.

This corresponds to conditions which frequently occur in tensile tests, namely, when the piece is gripped by means of projecting collars, the pull being in this case transmitted from the collar to the body of the cylinder by a system of axial shears.

It is found that the stress is greatest at the points where the shear is discontinuous, *i.e.* at the ends of the collar in a practical case. At these points it is theoretically infinite. For a short cylinder the tensile stress varies a great deal over the cross-section and the distortion of the latter is large.

The second problem is that of a short cylinder compressed longitudinally between two rough rigid planes, in such a manner that the ends are not allowed to expand. It illustrates the crushing of blocks of cement or stone between iron planes or sheets of millboard.

The greatest stress occurs at the perimeter of the plane ends and the "strength" is less than two-thirds of the strength under uniform compression. This result apparently contradicts the fact that the strength of stone or cement, when tested between lead plates, which allow of expansion, is very much less than when tested between millboards; but if we take into account the consideration suggested by Unwin ("Testing of Materials of Construction," p. 419) and corroborated by Prof. Ewing, that lead, which flows easily, may not merely allow, but *force* the expansion of the ends of the block, then it is shown that in tests between lead plates the strength may be much less than between millboards; moreover, such tests are indeterminate. The millboard test should give consistent results, though really introducing too large a factor of safety. The change in the form of the fracture noticed by Unwin is also confirmed by theory.

The third problem is that of the torsion of a bar in which the stress is applied, not by cross-radial shears over the flat ends, as the ordinary theory of torsion assumes, but by transverse shears over the curved surface. This corresponds to the case of a shaft or axle twisted by a frictional couple.

It is shown that the points of danger are those where the applied shear changes discontinuously. At a distance from these the solution rapidly degenerates into the ordinary type.

Physical Society, June 28.—Prof. Everett, F.R.S., vice-president, in the chair.—A paper on the effect of a high frequency oscillatory field on electrical resistance was read by Mr. S. A. F. White. The object of this paper is to discover if the action of light upon the electrical resistance of selenium can be imitated by using high frequency electrical oscillations. It is found that such oscillations permanently increase the resistance of selenium. The effect of a rise of temperature is to increase the resistance of a piece of low resistance and decrease the resistance of a piece of high resistance. The effects of the field in a piece of high resistance can be reversed by exposure to light or by reheating and subsequent cooling. In the case of tellurium a high frequency field temporarily decreases the resistance, as also does a rise in temperature. Repeated heating and cooling of a piece of tellurium permanently increases its resistance. It seems probable that all of the effects are due to rise of temperature caused by minute sparks within the mass. The rise in resistance by alternate heating and cooling may be due to the formation of tellurides with the metal of the electrodes. The large negative temperature effect of tellurium suggests that it might be usefully employed in the detection of heat radiation. The chairman expressed his interest in the paper and drew attention